2.7 Detection and reduction of noise

When various sensors are used as in meteorological observations, the measurement values are sometimes affected by noise. Turbulence observations are particularly susceptible to the effects of noise because the sampling rate is relatively high, ranging between a few Hz to a few tens of Hz, and because the measurements require resolutions higher than those sought for general meteorological observations. The noise that affects turbulence observations can be roughly classified into three types:

1) Electrical noise transmitted by signal cables
2) Electromagnetic noise transmitted in the air
3) Noise transmitted by power supply lines (AC power supply lines)

Electrical noise transmitted by signal cables is generated when the insulation resistance or shielding of the sensors is insufficient, or when the signal cables are affected by a power line, a pump, a motor, or electromagnetic waves. Caution is required when wireless equipment such as cell phones and wireless LANs are used for data transmission and monitoring of observation systems as the use of these kinds of equipment causes electromagnetic noise. Noise induced by power supply lines includes instantaneous power failure (indicated by zero voltage for a short time interval such as one cycle), harmonic current (distortion of the original AC waveform due to high-frequency current), voltage drop (voltage drop due to a capacity shortage of the power source or a large distance from the switchboard), and flicker (low-frequency oscillation of the power supply voltage). Particularly when observations are conducted in remote sites or in the areas at which the power supply is unstable, the investigator needs to pay attention to the condition of the supplied power.

Noise detection

The use of commercially available instruments for turbulence observations does not usually pose any serious noise-related problems because those instruments are equipped with sufficient noise-reduction measures. However, at the beginning of an observation or with the replacement of an instrument, the data need to be checked to make sure that they are free of abnormalities.

The most basic data checking procedure is to plot and check the raw measurement values while all the measuring instruments are connected. If the measurement values include spikes, biased values, or ripples related to the power supply frequency, abnormal values will be noticeable even in the data collected at the measuring frequencies that are usually adopted for turbulence observation (approximately 10 Hz). Data can be checked in more detail for noise if the data signals are monitored by an oscilloscope or a spectrum analyzer. When noise is found, the source needs be identified. However, there is no set way to identify the source of noise, and the source can be detected only through trying out various possibilities such as reconnecting signal cables, changing the power supply system, and turning off electric devices such as pumps.

Because the power source can easily cause noise and instrument malfunctions, it is important to check the condition of the AC power source. The power supply voltage can readily be tested with a tester. Various types of power-supply related noise such as those described above can also be checked with an oscilloscope.

Measures to reduce noise

(1) Signal cables

When noise is generated due to insufficient insulation resistance or shielding of a sensor, it is recommended that the sensor be replaced with a reliable one. When a signal cable transmits noise, there are several possible noise suppression measures: keep the cable away from the noise source (e.g., electric devices and wireless LANs); avoid looping the surplus cable; use a twisted pair cable or a shielded cable; keep the signal cable and the power transmission line some distance apart; and cover the signal cable with metal foil or run the cable through a metal pipe.

The sampling frequency used for turbulence observations is approximately 10 Hz, and high-frequency components including the components at the power supply frequency (i.e., 50 Hz or 60 Hz) or higher are spurious. Therefore, it is also effective to apply a low-pass filter (approximately 25 Hz) to the signal cables as in Photo 2.7-1.

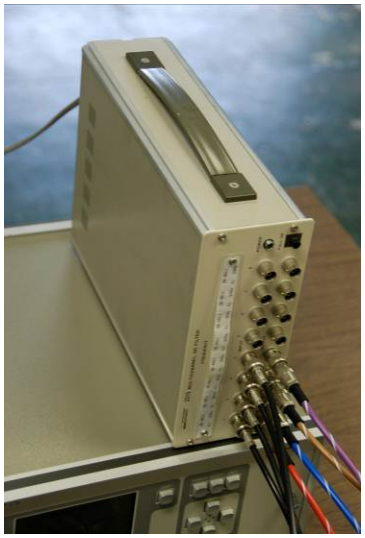

Photo 2.7-1 Low-pass filter for signal cables.

(2) Electromagnetic waves

Cell phones, wireless LANs and CPUs can be sources of noise. Measuring instruments should be kept away from such equipment and should be shielded with metal or other conductive materials.

(3) Power supply

It is effective to apply a noise cut transformer or a lightning shielding transformer to the power supply circuit in order to suppress extrinsic high-frequency noise and surges (Photo 2.7-2). Problems due to instantaneous power failure or voltage fluctuations can be avoided by including an uninterruptible power supply (UPS) in the power supply circuit (Photo 2.7-3). The investigator needs to be also aware that noise may be generated by the switching power supply that is used for supplying DC power to various measuring sensors.

Photo 2.7-2 Noise cut transformer for power supply.

Photo 2.7-3 Uninterruptible power supply unit (UPS).

It is sometimes quite difficult to identify appropriate measures for noise reduction. In designing an observation system which is robust against noise, the following points should be kept in mind:

1) The power supply for the measuring instruments should be separated from that for other electric devices. The use of a noise-cut power transformer is effective to separate the measuring system from other components.
2) When a transformer or a filter is used, the primary and secondary lines should be wired separately and in such a way that they do not get close to each other.
3) The power and signal lines should be kept as far apart as possible. When it is unavoidable to cross the two, they should meet at right angles. When the power and signal lines are installed in an observation hut or on an observation tower, each line should be inserted through separate cable outlets and/or separate vertical pipes so that each line is clearly separated from the other.
4) The signal cable should be made as short as possible to avoid looping.
5) The measuring instruments, data loggers, and signal cables should be kept from devices which produce noise.
6) The earth connection should be carefully arranged. The grounding wires of all measurement instruments should be connected together and to a solid earth terminal.

Tips!

In recent years, an increasing number of turbulence observation instruments provide digital output. Digital output is often less susceptible to noise than analog data output; thus, the use of digital output is recommended if it is compatible with the data logger.

Tips 2.7-1